

Effects of chemical treatments on dormancy breaking and some sprouting characteristics of two potato cultivars in different tuber sizes

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ABSTRACT

Seed potato dormancy has been considered in breeding programs, virus-free seed producing and ware potato production. Seed dormancy is different between potato cultivars. Dormancy in potato mini-tuber buds is one of the limiting factors on planting them after harvesting. This study was undertaken in a factorial based on complete randomized design with arrangement three replications to investigating the effect chemical treatments, cultivars and seed size on seed dormancy breaking of potato in 2011-2012 at Seed and Plant Certification and Registration Institute. The results showed that the chemical materials was significant at ($p < 0.01$) on number of days to sprouting, number of days to dormancy breaking and the total number of sprouting. Number of sprouting per tuber and number of days to sprouting and dormancy breaking between two cultivars were different. Utilization of Gibberellic acid reduced the sprouting time from 25 to 13 days. The lowest number of days to dormancy breaking in average of 28.8 days was obtained in applying GA3 on 20-25 mm mini-tuber. Thio-urea application had the most effect on decreasing the days to emergence in average of 25.1 days and also increased number of sprout from 1.41 to 2.03. The result of this project showed that with increasing the mini-tuber size, the days to dormancy breaking decreased and also the number of sprout. Therefore application of GA3 is advisable for decreasing days to sprouting, accelerating sprout length and consequently resulted in breaking mini-tuber dormancy of potato for short time.

Keywords: Dormancy breaking, Mini-tuber, Gibberellic acid, Thio-urea, Carbon di-sulphid.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is considered as an important and strategic product, having the second rank in terms of production and third one according to its importance among other produced foods in Iran [2]. One of the most popular ways to produce pre-basic seed of potato (*Solanum tuberosum* L.) is to grow mini-tubers in the greenhouse from *in vitro* plantlets produced from nodal cuttings. Mini-tuber production has found its place in the seed production systems all over the world as it creates a bridge between the *in vitro* rapid multiplication based on nodal cuttings and the field multiplication of seed tubers. Mini-tubers are more flexible, can be stored and mechanically planted, and show a larger vigour than either microtubers or *in vitro* plantlets [17].

Lack of good quality seed among growers is a major problem adversely affect the expansion of potato production in many developing countries[5]. One major problem facing production of quality potato seed is poor sprouting, due to dormancy, which lead to delayed planting and poor crop emergence and vigor [18]. After harvest, normal seed tubers show dormancy for about 1–15 weeks, depending on cultivar, tuber size, conditions before harvest and storage conditions. Small tubers, such as mini-tubers, even have longer periods of dormancy [12] and are more sensitive to adverse conditions during storage [17] In Iran, a large amount of mini-tubers is harvested between March and April. Normal planting time of these mini-tubers in the field or in the greenhouse is in the month of May or beginning of June. So there is not enough time between harvest and planting to break dormancy naturally. This

calls for are liable technique to break the dormancy of these small tubers chemically. Use of low quantities of growth promotes like thiourea, rindite, carbon disulphide and bromo-ethane [3] and gibberellic acid [4,6] to promote potato seed sprouting has been suggested. This study under taken to evaluate the effect of growth promotes and size on dormancy breaking of mini-tubers of potato.

MATERIALS AND METHODS

This study was done in the greenhouse of SPCR Institute (Seed and Plant Certification and Registration research Institute) in Karaj, Iran. This research carried out in form of factorial based on randomized complete design in three replications. Experimental factors were considered chemicals as the first factor in four levels (control, 50 g/lit gibberellic acid, 25 ml/m³ carbon disulfide, 3% thio-urea), potato cultivars as the second factor in two levels (Agria and Burren) and potato mini-tuber size as the third one in four levels (12-20 millimeter, 20-25 millimeter, 25-30 millimeter and 30-35 millimeter).

2.1. In Vitro Seedlings Production

Virus-free seedlings were produced using combination method of heat treatment and meristem isolated and cultured in MS liquid medium onto paper bridges and then transferred cultures in suitable growth condition in the growth chamber. Obtained seedlings using single-node cuttings on solidified MS medium multiply with agar and were transmitted to a growth chamber with a temperature of 24 degrees Celsius, light for 16 hours and light intensity of 4500 lux and were kept there about 4 weeks to grow and become the new seedlings

2.2. Mini-tuber Production in Greenhouse

After obtaining the required number of seedlings from each cultivar, seedlings 25-30-day lifetime having 7 to 9 leaves were selected for transfer to greenhouse. In the greenhouse, seedlings were brought out of the pots and the roots were washed with water to remove medium residual matter. Cleaned seedlings transferred carefully into the bed including a mixture of soil disinfected by fungicides and insecticides and perlite and peat moss in the ratio of 1: 2: 1 and for a few days plastic cap was placed on them to adapting seedlings with greenhouse environment and preventing damage to seedlings. Seedlings were growth in growth chamber with day and night temperatures of 18 and 12 ° Celsius respectively, 12 hours day length and 85% relative humidity. After passing about 100 days, the mini-tubers were harvested and transferred to laboratory for sprouting. After selecting mini-tubers but prior the applying chemicals and growth-stimulating hormone mini-tubers were washed with water and placed in a tray.

2.3. Gibberellic acid Treatment

Sample containing 240 mini-tuber of each cultivar were immersed for three hours by 50 ppm gibberellic acid treatment solution in groups (12-20 millimeter, 20-25 millimeter, 25-30 millimeter and 30-35 millimeter) and then samples were placed into plastic tray with room temperature for germination.

2.4. Thio-urea Treatment

Sample containing 240 mini-tuber of each cultivar were immersed by thio-urea 3% solution for one hour in groups (12-20 millimeter, 20-25 millimeter, 25-30 millimeter and 30-35 millimeter) and then samples were placed into plastic tray in garner with 90 relative humidity, absolute darkness and temperature of 18 ° C for germination. 60 micro-tubers from each cultivar was placed immediately after harvest and washing with distilled water in standard storage conditions as a control treatment without the application of hormones and chemicals. The time interval between the applications of chemicals till to sprout emergence in micro-tubers was recorded. Emergence of sprout about 2 mm from tubers is an appropriate criterion for dormancy period ending and whenever 80 percent of mini-tubers show that symptoms it consider as dormancy break time. During the experiment, tubers having sprout were counted and were separated every 10 days. Average of 2 mm sprouts of each micro-tuber was recorded one week after the end of dormancy.

2.5. Carbon Di-sulfide Treatment

For the carbon disulphide treatment, 240 mini-tubers were put in 15×19×32 cm plastic containers with tightly fitting lids at room temperature for 72 h. Sufficient CS₂ was supplied in liquid form in 25 ml beakers to give the required concentration in the container volume. 60 micro-tubers from each cultivar was placed immediately after harvest and washing with distilled water in standard storage conditions as a control treatment without the application of hormones and chemicals.

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2.6. Statistical Analysis

To analyze this study's obtained data applied ANOVA analysis procedure of SAS software. For downing the mean comparisons LSD test was used by a probability level of 5%.

RESULTS AND DISCUSSION

3.1. Days to Sprouting

According to Table 1 results of analysis of variance laboratory traits shows that all of experimental factors main and interaction effects was significant ($P < 0/01$) on days to sprout emergence. But tripartite effect did not the same significant differences. The highest days to sprouting were observed by average of 25.2 days in control and the lowest days obtained in gibberellic acid treatment by average of 13.9 days. Based on achieved results application of all three growth regulators hormones used in this experiment, reduces the number of days until the appearance of the sprout. It seems that application of growth regulators and gibberellic acid most of all, causes to postponement of sprouting which is in consistent by Helsinki *et al.*, [9] and Gomez and Martinez [8] results.

It is worth noting that the number of days to sprouting showed different results in two varieties that could be stated due to different physiological characteristics of different varieties. It was also observed that the number of days to sprouting, depending on seed size showed different results. So that just 30 to 35 mm with an average of 17.8 days significantly affected the number of days to sprouting compare to the other sizes. Results of Khorshidi and Hassanpanah [11] also showed that increasing the seed size increases monotonically on the size of the sprout, but it can be linked to the most vigorous seeds of larger seed for creating bigger sprouts.

3.2. Total number of sprouting

The results (Table 1) showed that the application of growth regulators and seed tubers varieties and different sizes was able to have a significant effect on the total number of sprouting.

The results of this experiment can be stated that the use of chemicals used in these experiments was increased total number of sprouting of potato. In this study, compare to control chemicals treatments increased total number of sprouting, that among the all, highest rates in sprout length belongs to the application of Thio-urea. The results of these experiments is consistent with the results of the Rehman *et al.*, [13]. It should be noted that the total number of sprouting in *Burren* cultivar 1.92 was higher than the *Agria* cultivar (table 2). These differences can occur due to various physiological habits. Also difference in seed size as well causes a difference in number of the sprout. So that the number of sprout increased whatever as well as seed tuber size increased. This indicates the importance of nutrient available storage in the seed tubers.

3.3. Days to Dormancy Breaking

Achieved results of these experiments revealed that the application of plant growth regulator hormones causes significant differences in the number of days to break dormancy in compare to control. It is worth noting that the difference created by the gibberellic acid in turn was different from the other two hormones. The lowest Day to break dormancy was observed in gibberellic acid hormone application by the rate of 33.50 days which in comparison to highest rate observed in control plots (54.7), the difference is significant and unavoidably (table 2). Dogonadze *et al.*, [7] reported that with respect to that in addition abscisic acid another ingredients involved in tuber natural dormancy, application of gibberellic acid on dormant tubers can reduce endogenous abscisic acid of tubers. The reports also state that gibberellic acid causes breakdown of starches and accumulation of renewable sugars in potato tubers which this issue that can stimulates the germination and consequently the dormancy breaking [1,10]. Some other reports has been stated that dipping the seeds with gibberellic acid before planting for an hour, will break seed dormancy of the potato [13]. However, we have to consider the fact that excessive use of gibberellic acid causes disorders such as stem elongation [14] excessive growth of the shoots, tuber deformities, delay in tuber angiogenesis and reduction in root formation.

Days to break dormancy in *Agria* was lower than the result *Burren* cultivar showed. Differences in this characteristics have been observed in different varieties in the other experiments. In Salimi *et al.*, [16] experiments also *Burren* and *Agria* cultivar achieved longest and shortest dormancy period. Mean comparison table shows that the average dormancy duration inversely with the amount of seed size (table 2). This means that whatever size of the tuber has grown bigger dormancy period fell by. It can be said that this is probably due to the larger potato seeds contain higher levels of dormancy inhibitors. Results of this study were similar to results reported in earlier studies [15].

Table 1- Analysis of variance for laboratories traits

SOV	Degree of Freedom	Days to Sprouting	Total number of sprouting	Days to Dormancy Breaking
Growth stimulants(A)	3	519.29**	1.51**	2220.59**
Variety (B)	1	37.76**	3.36**	319.01**
Mini-tuber size (C)	3	18.08**	1.90**	204.84**
A * B	3	35.83**	0.03 ^{ns}	26.68*
A * C	9	2.20**	0.17*	37.51**
B * C	3	8.65**	0.50**	20.98 ^{ns}
A * B * C	9	1.08 ^{ns}	0.09 ^{ns}	14.50 ^{ns}
Error	62	43.01	0.07	9.33
CV	-----	4.35	15.59	7.53

*, ** and ns: Significant at the 5% and 1% level of probability and non-significant, respectively.

Table 2- Mean comparison of main effects

Experimental Treatment	Days to Sprouting(day)	Total number of sprouting	Days to Dormancy Breaking (day)	
Growth stimulants (A)	Control (wash by water) (a ₁)	25.24 d	1.41 c	54.75 c
	gibberellic acid (a ₂)	13.99 a	1.71 b	33.50 a
	carbon disulfide (a ₃)	18.04 b	1.76 b	37.58 b
	Thiourea(a ₄)	19.13 c	2.03 a	36.75 b
Variety (B)	agria (b ₁)	19.73 b	1.54 b	36.85 b
	Burren (b ₂)	18.47 a	1.92 a	33.23 a
Mini-tuber size (C)	12-20 (c ₁)	19.60 b	1.47 c	45.54 b
	20-25 (c ₂)	19.36 b	1.52 c	42.54 b
	25-30 (c ₃)	19.62 b	1.87 b	38.45 a
	30-35 (c ₄)	17.81 a	2.06 a	37.66 a

Mean in each column, followed by similar letter (s) not significantly different at 5% probability level, using LSD test.

Table 2- Mean comparison of interaction effect

Experimental Treatment	Days to Sprouting (day)	Total number of sprouting	Days to Dormancy Breaking (day)	
Control (wash by water) (a ₁)	Agria (b ₁)	25.38 a	1.27 a	57.50 b
	Burren (b ₂)	25.11 a	1.55 a	52.00 a
gibberellic acid (a ₂)	Agria (b ₁)	16.42 b	1.50 a	36.00 b
	Burren (b ₂)	11.56 a	1.93 a	31.00 a
carbon disulfide (a ₃)	Agria (b ₁)	18.27 a	1.59 a	38.00 a
	Burren (b ₂)	17.82 a	1.94 a	34.75 a
Thiourea(a ₄)	Agria (b ₁)	18.85 a	1.80 a	37.17 a
	Burren (b ₂)	19.41 a	2.25 a	38.00 a
Control (wash by water) (a ₁)	12-20 (c ₁)	25.53 b	1.35 a	59.67 c
	20-25 (c ₂)	25.20 b	1.32 a	57.67 bc
	25-30 (c ₃)	26.42 b	1.40 a	53.33 b
	30-35 (c ₄)	23.82 a	1.52 a	48.33 a
gibberellic acid (a ₂)	12-20 (c ₁)	15.23 c	1.46 b	39.33 b
	20-25 (c ₂)	14.52 bc	1.33 b	35.33 b
	25-30 (c ₃)	13.47 ab	1.98 a	28.83 a
	30-35 (c ₄)	12.76 a	1.35 a	30.50 a
carbon disulfide (a ₃)	12-20 (c ₁)	18.29 b	1.56 c	37.33 a
	20-25 (c ₂)	18.45 b	1.83 bc	39.83 a
	25-30 (c ₃)	19.15 b	2.31 b	37.17 a
	30-35 (c ₄)	16.30 a	1.83 a	36.00 a
Thiourea(a ₄)	12-20 (c ₁)	19.38 a	1.71 b	37.83 a
	20-25 (c ₂)	19.28 a	1.88 b	37.33 a
	25-30 (c ₃)	19.48 a	2.28 a	34.50 a
	30-35 (c ₄)	18.37 a	2.23 a	35.83 a
Agria (b ₁)	12-20 (c ₁)	19.65 ab	1.32 b	45.42 a
	20-25 (c ₂)	19.62 a	1.53 b	43.42 a
	25-30 (c ₃)	20.44 b	1.62 b	39.92 a
	30-35 (c ₄)	19.20 a	2.21 a	40.75 a
Burren (b ₂)	12-20 (c ₁)	19.56 b	1.52 b	41.67 a
	20-25 (c ₂)	19.09 b	1.80 b	41.67 a
	25-30 (c ₃)	18.81 b	1.52 a	37.00 a
	30-35 (c ₄)	16.42 a	2.31 A	34.58 a

Mean in each column, followed by similar letter (s) not significantly different at 5% probability level, using LSD test.

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